INTERACTION MEET
ON
EARTH SCIENCES FOR NE INDIA
AT IMPHAL

(8th-9th April 1996)

Sponsored by

Department of Science & Technology
Government of India
New Delhi

Organised by

Department of Earth Sciences
Manipur University
Canchipur, Imphal

BACKGROUND

Northeastern India, comprising seven sister states *viz.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura is situated in the remote corner of the country having a distinct geographic entity. Between this region and the mainland there is an increasing gap of research activities in the field of Earth Sciences due to poor transportation and communication among the sister states as well as between the region and the rest of the country, lack of infrastructures and its natural & social constraints. In order to narrow down the widening gap, Department of Science and Technology, Government of India sponsor an Interaction Meet for Earthscientists of Northeast India at the Department of Earth Sciences, Manipur University, Imphal to discuss and encourage Earthscientists of the region in formulating and submitting research proposals on the emerging fronts of Earth Sciences and on the Thrust and Challenging areas of the region to be identified during the Meet.

OBJECTIVES

The objectives of the meet are

1. to interact among the Earthscientists of Northeast India as well as with Earthscientists of other parts of the country with a view to identify the thrust and challenging areas of the region so as to direct the future course of research activities in the field of Earth Sciences.

2. to discuss about the co-ordination among the Earthscientists and various organisations of the region and to identify areas of common interest where joint venture research activities can be taken up.

THRUST AND CHALLENGING AREAS

Due to a number of natural & social constraints, lack of infrastructures etc. Northeastern India is far lagging behind in its basic studies and information about Earth Sciences in comparison with other part of the country. So any kind of work in the field of Earth Sciences may be treated as a thrust (or part of) area. A lenient approach may, therefore be adopted by the funding agencies specially DST, Government of India in providing financial assistance to research proposals submitted by any Earthscientist of the region. However some of the thrusts area identified by the Department of Earth Sciences, Manipur University have been highlighted below:

1. *Seismic monitoring and Neotectonics.*
2. *Natural/Man-made hazard investigations*
3. *Structural and tectonic framework studies.*
4. *Petrochemical studies of ophiolites and associated sediments*
5. *Basinal analysis, petrochemistry and sedimentation studies*
6. *Geotechnical studies*
7. *Groundwater development and quality studies*
8. *Geoenvironmental studies of the lakes of the Imphal valley and other catchment area*
9. *Mineral resources studies and*
10. *Hydrocarbon potential studies.*

GEOLOGICAL NOTE ON NORTH EAST INDIA

INTRODUCTION

North Eastern Region falls under parallel N 21°-57' to 29°-30' and meridian E 89°-46' to 97°-30' and encompasses an area of 2,55,000 sq.km. approximately. It comprises seven states *viz* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. The Northeast region can be geographically divided into three distinct physiographic units *viz* Assam valley, Purvanchal and Meghalaya Mikir region. The Assam valley is well demarcated by a physical unit within the girdle formed by the eastern Himalayas, Patkai in Naga hills, Garo-Khasi-Jaintia and Mikir hills. The valley includes the administrative districts of Lakhimpur, Sibsagar, Nowgong, Darrang, Dibrugarh, Kamrup and Goalpara of Assam. Purvanchal region encompasses Nagaland, Manipur, Tripura, Mizohills, Cachhar and Arunachal Pradesh. The Meghalaya-Mikir includes the state of Meghalaya, Mikir hills and a portion of Cachhar hills of Assam.

Physiographic divisions are Northeastern Frontier Mountain Ranges, Southeastern Hill Ranges, Meghalaya Plateau and Assam Valley and Cachhar Plains. North Eastern Frontier Ranges extend from Tista River in Sikkim to Namcha-Burma Peak in the Mishmi hills. The region is divisible into several sections mainly Bhutan Himalayas extending from Sikkim to Dhansiri river, Akahills from Dhansiri to Dikorai river, the Daffa hills from Bharali river in west to Ranganadi in the east, the Mikir hills in the North of Lakhimpur district, Abort hills between Bihing and Disang river.

Southern hill ranges include the Patkai, the Naga, the Barail hills, the high land of Manipur and the Lushai hills or the Mizo hills. The entire region is very much undulating except Manipur Valley. Manipur valley is about 752 mts (MSL) and surrounded by high hills. The Patkai and Naga ranges form waterdivide between India and Burma.

The Meghalaya plateau consists of the Garo hills, Khasi-Jaintia hills and Mikir hills. The southern face of Garo and Khasi hills rises abruptly from the plains. The plateau is surrounded in three sides by the plains of Brahmaputra, the Surma and the Kopili river. There are deep gorges formed by the rivers carrying the enormous rainwater of the region.

The Brahmaputra valley is an alluvial plain, lying between North Eastern Frontier Ranges, Patkai and Naga hills and Meghalaya Plateau. The Brahmaputra river passing through the middle of the valley has deposited a few hundred meters thick alluvium covering the underlying compressed sedimentary rocks.

The Cachhar plains has a length of about 200 km and breath a of 96 km. The Surma river passes through the Cachhar district and is covered with a sluggish stream and saucer like depressions.

REGIONAL SETTING

The Indo Myanmar Range (IMR) is considered to be the northern prolongation of Indonesian Island, which in turn is linked up northward with the eastern end of the Himalayas. The IMR are divided into three sections from north to south *viz.* the Naga-Patkai Hills. the Chin Hills and the Arakan-Yoma Hills. The Indian Plate consists of Peninsular Shield characterised by metamorphic rocks with late Palaeozoic-Mesozoic intra cratonic continental Goundwana Basin, Cretaceous-Palaeogene flood basalt, Mesozoic-Cenozoic shelf facies occur along the coastal tracts, around Rajasthan to the west and Bengal-Assam basin to the north east. On the other hand, the Tibetan and the Thai Burmese plates consist of cratonic blocks and the Palaeozoic-Mesozoic mobile belts. Nearly all along the northern margin of the Himalayas and the eastern margin of the Indo Burmese Range, Late Mesozoic Ophiolite rocks occurs along tectonised belts. e.g. Indus-Tsangpo zone and Naga-Arakan-Yoma-Andaman belt. The north- south trending 2000 km long, sigmoid Naga-Andaman belt of ophiolites, is represented by basic volcanics and Ultramafic rocks, closely associated with late Mesozoic oceanic sediments.

The narrow tectonised ophiolite belt is believed to represent the remnants of the Tethyan (Neo-Tethyan) oceanic crust which was largely subducted, resulting in the collision of Indo- Australian plate with Eurasian (Tibetan) and the Sunda (Cathy asian) plates. The Naga Hills representing the northern end of the IMR and the Himalayas are generally regarded to have been formed by continent -continent collision. In the southern section of IMR, the frontal collision zone forming a belt of schuppean thrust gives place to broadly N-S trending folds belts. The weak frontal folds are still growing offshore and onshore in the eastern part of the Bay of Bengal adjacent to the Andaman Nicobar. (Moore *et. al*. 1980). A brief Geological description of various physiographic-cum-Tectonic belts/units is given below :

The Shillong and Mikir Massifs forming a north-eastern prolongation of the Indian shield, occur as a pivot to the west of the Naga hills and south eastern end of the Himalayas. The high grade metamorphic basement rocks are unconformably overlain by less deformed Proterozoic shelf sediments comprising of the Shillong Group with the meta volcanic Khasi greenstone and Late Pre Cambrian granite plutons.

The Eastern Himalayas, similar to the western section from south to north may be sub divided into the sub Himalaya, Lesser Himalaya, Great/Central Himalaya and Tethyan/Trans-Axial Himalaya. The north Brahmaputra Sub Himalayan basin mainly consist of Neogene and Quaternary molasse sediments, which are terminated to the North by Main Boundary Thrust against the Pre Tertiary rocks of Lesser Himalayas. The homoclinal northerly dipping formation of Sub Himalayas are correlated to the Middle and the Upper Siwalik formations of the Western Himalayas. There is a broad similarity between the sediments of the Sub Himalayas and Neogene Quaternary Molasse sediments of Naga foothills. Pre Tertiary low grade metamorphosed rocks of the Lesser Himalayas tectonically underlie the central Crystalline and the tectonic contact is defined as the Trans Axial Thrust. The Trans Axial sedimentary sequence represents nearly complete Phenerozoic epicontinental fossiliferous sediments of Tethyan affinity with a few minor breaks and is thus known as the Tethyan Himalayas. The Lesser

Himalayan sequence, both stratigraphically and structurally truncated, essentially consists of Late Palaeozoic sediments and unfossiliferous low grade metasediments. Lesser Himalayan rocks, specially in the north eastern sector are associated with basic and acid volcanics and volcanoclastics. The thick unmetamorphosed flyschoid sediments, with Eocene floral and microfaunal associations, occur in close association with basic volcanic represents a composite unit in which products of a younger volcanic activity are also included (Tripathi *et. al.* 1981).

The significant details about the Tsangpo (Zangbo Ophiolite) and Trans-Himalayan magmatic arc are known mainly between the north of Mount Everest and south of the Lhasa (Anon, 1980; Tapponier *et.al,*1981; Shackleton, 1981; Allegre *et. al.*, 1984).

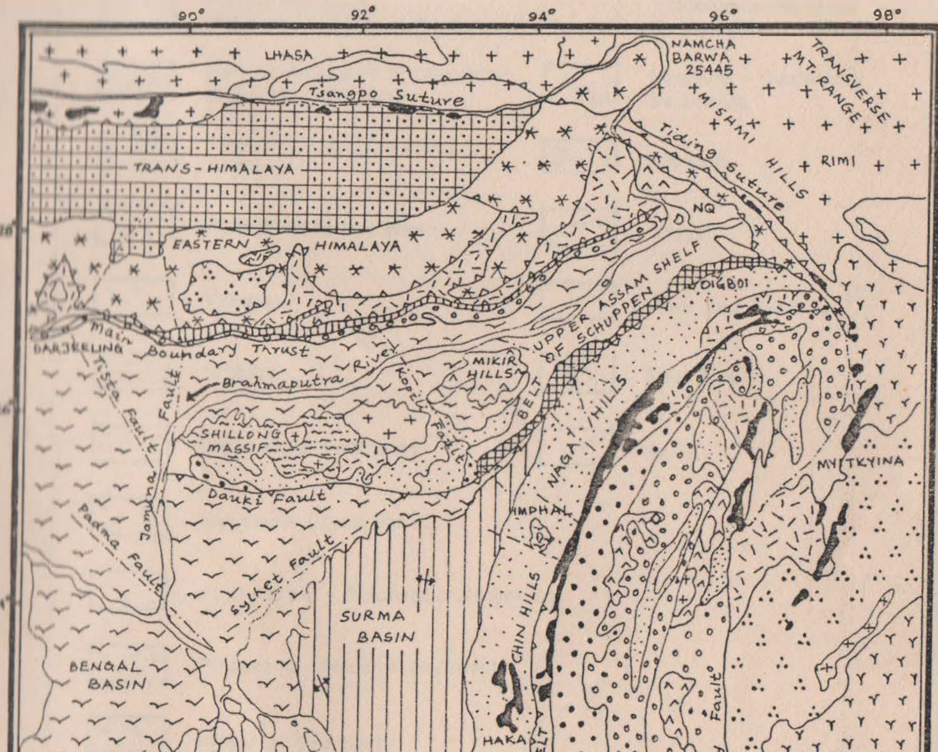
Basal clastic sediments of arc trench basin at places grade to oceanic pelagic sediments over the oceanic crust with radiolaria rich horizons at the base which are of Upper Albian to Lower Cenomanian Age. The conglomerates, and grits, intercalated with red siltstone in the lower sections of the Xighase Group are coarsely graded showing flute markings. Pebbles of variegated chert and volcanics are apparently derived from the ophiolite belt to the south. The higher beds are also conglomeratic, containing clasts of the plutonic and volcanic rocks from Gangdise magmatic arc to the north. These beds also stratigraphically transgress, at places, over the plutonic complex. Similar trench sediments also occur as wedges within the ophiolite zone. The southern and lower sections of the Tsangpo ophiolites are represented by the melange zone with tectonised Ophiolite members and radiolarites of Jurassic to Cretaceous age. The deformation is intense within the Ophiolites zone especially close to its southern side which juxtaposed against the Mesozoic sediments of the Tibetan Himalayas. The Mesozoic flysch with exotic and ophiolite rocks and ophiolite melange also occurs as thrust embayments and klippe over the Tibetan Himalayas to the South. The Gangdise magmatic arc, with copious calc-alkaline volcanic and plutonic rocks, lies parallel to the north of the Tsangpo Ophiolite belts and physically link up with Indus ophiolite and Ladakh magmatic arc indicating a north dipping Benioff zone. The Gangdise batholith, one of the largest in the world, broadly shows a belt like pattern, from south to north, with intermediate and acid rocks types.

These plutons intrude the folded marine Mesozoic sediments and are usually unconformably succeeded by the undulating continental upper Cretaceous-Palaeogene calc-alkaline volcanics. Epicontinental Palaeozoic sediments are similar to Central Tibet, north of Tsangpo zone. Late Palaeozoic diamictite, basic intermediate volcanics, volcanoclastics and Tethyan-peri-Gondwana type fauna have been reported from Lhasa and other areas of Tibet.

The Mishmi Hills occur at the junction of the Eastern Himalayas and IMR. There are contrasting tectonic models with divergent views about the significance of the NW-SE trending Tidding suture and its serpentinites, metavolcanics, metasediments and huge Mishmi diorite-granodiorite batholithic complex occurring on its back (Nandy, 1981, 1982, 1983; Mitchell 1981; Acharya, 1982; Chattopadhya and Chakraborty, 1984). The rocks of eastern Lesser Himalayas and Central Crystalline appear to be greatly attenuated and truncated in the Mishmi Hills by Lohit thrust zones to Tidding suture and

LITHO-TECTONIC MAP

North East India



(Modified after various authors)

LEGEND

- Lesser Himalaya (Palaeozoic-Neogene Sediments)
- Belt of Schuppen (Palaeogene-Neogene Sediments)
- Trans-Himalaya (Mesozoic Sediments)
- Plutons (Acid and Basic)
- Volcanics
- Archaean
- Proterozoic Sediments
- Himalayan Crystalline
- Proterozoic - Palaeozoic Sediments
- Palaeozoic-Mesozoic Sediments
- Mesozoic Sediments
- Ophiolite Belt
- Mesozoic-Palaeogene Sediments
- Palaeogene Sediments
- Neogene Sediments
- Palaeogene-Neogene Sediments
- NQ Neogene - Quaternary Sediments
- Alluvium
- Thrust
- Fault and Fracture
- Fold Axis
- River

Mishmi frontal thrust zone to the south east. Continuity of the narrow Tidding suture has been recognised in the upper reaches of the Siang river.

Assam shelf areas flank Shillong-Mikir massifs with the slope of the basement both towards the northeast and southeast (Dasgupta, 1979). The Lower Gondwana sediments of Talchir and the Barakar Formations (Permian) occur only in the Northeastern tip of Shillong Massif. The prominence of Lower Gondwana miospores in the younger Tertiary sediments documents larger spread of Gondwana basin of the cratonic area than those exposed now, south of Shillong, basic volcanic flows of a Sylhet Trap overlies the basement, which continues in depth, in Garo Hills and in the Mikir Hills to the northeast. Recent fission track dating of apatite of alkaline ultramafic carbonatite complex from central Mikir Hills suggest possible contemporaneous mantle activity. The Cenozoic sedimentation on the Assam Shillong shelf begins with the deposition of the Jaintia Group of Palaeocene-Eeocene age which has a large spread in the Upper Assam sub surface and in the Mikir Hills. It is mainly made up of basal arkose, blanket limestone and black shale association of stable to slightly unstable shelf and littoral to sub littoral environment (Murthy 1983). The basinal areas during the depositions of the Barail intermittently witnessed shallow marine, lagoonal and deltaic and estuarine environment.

The outer molasse basin stretches from the outer Naga foot hills, to the Surma valley in Tripura. It is best developed in the latter area. The early molasse correspond to the Tipam Group and younger sediments. The Surma Group rests on the denuded surface of the Barail, the oldest exposed unit of the molasse basin. The unconformity is pronounced near the periphery of the basin but it loses its identity towards the deeper parts. The Surma Group and younger sediments attain more than 4000 m thickness in deepest part in Tripura (west of Agartala).

The Surma type areas are broadly deltaic sediments. In Naga Hills, the Surma Group is considered to be the Lower Middle Miocene; in Surma valley the adjacent Cachhar Hills, the upper age extends to Upper Miocene; while in Tripura, the upper unit yields Lower Pliocene fossils suggesting that both base and top of Surma Group, in different parts of the molasse basin, are significantly diachronous.

Two sedimentary tectonic zones have been recognised within Indo-Myanmar belt. The Central Naga Hills Palaeogene Basin of flyschoid sediments occurs in the west i.e. towards the outer side, while the Naga and Chin Hill Ophiolite occur towards the east or inner side. The western sedimentary belt essentially consists of folded and thrusted thick pile of monotonous flyschoid Disangs, succeeded by the sandy flyschoid to Molassic Barail Formation within this belt. The thick monotonous argillaceous succession of Disangs is generally considered to be a flysch sequence (Mathur and Evans, 1964; Rao 1983). Typical turbidite sequences are locally developed, especially within the Upper Disang and the Basal Barail. There is a perfect lithological and faunal continuity between Upper Disang and Lower Barail where arenaceous beds become dominant gradually. Shallow marine fauna and plants fragments are recorded from the Barails. The Distal shelf to flyschoid facies of the Disangs grade upwards to sandy flyschoid to molassic facies within the Barail Group.

In Kohima synclinorium, complexly folded Disang and Barail successions with hook shaped fold closer is unconformably overlain by the open folded basal units of the Surma Group. The tectonised and dismembered ophiolite members of Naga Chin Hills have thrusted over the Disang Formation to the west, whereas to the east, the Ophiolite rocks or their sedimentary cover are in places, overthrusted by the Naga Metamorphics or other equivalents. Further east, the metamorphics occur unconformably below the Mio-Pliocene molasse of the Central Burma Basin. In Nagaland and Manipur, the ophiolite belt occurs as a NNE-SSW trending, westerly convex arcuate belt. The dismembered ophiolite suite is non-conformably overlain by the newly christened Phokphur Formation comprising a sequence of ophiolite derived volcanic clastics, marine to pelagic sediments that are broadly dated as Eocene. It is folded, imbricated with ophiolite basement, overriden by the Naga Metamorphics, variably deformed and at places feebly metamorphosed. Narrow ophiolite slices occur within the Disang like sediments in the southern sector (Manipur). It is possible to recognise equivalents of Phokpur Formation from these undifferentiated Disang Formation which occurs in strike continuity of the Phokpur, containing clasts of ophiolite rocks.

The Eastern Burmese Highlands, Shan plateau and Peninsular Burma-Thai-Malaysia constitute the Highland of Eastern Burma. The Myitkyina and Mandalay Ophiolite belt occur along the northern part of the tectonised margin between the Central Burma Molasse Basin and the East Burmese Highland. Serpentinites, gabbro, amphibolite and basaltic andesite and locally trachytic volcanics have been recorded. The volcanics are often amygdaloidal. The Ophiolite suite and associated metamorphic rocks are unconformably overlain by the Tertiary sediments.

TECTONICS, SEISMICITY AND GRAVITY OF NE INDIA AND ADJOINING REGION

The broad geological frame work of NE India including IMR and Eastern Himalayas along with their linkage with the adjoining region of southern Tibet and Myanmar are discussed on the basis of seismicity and gravity features within the frame of parallel N 20° to N 31° and meridian E 88° to 98°. The major and significant tectonic elements recognised from the study of lineaments are as follows :

i. In the Bengal Basin, the important faults are NW-SE and NE-SW trending with fractures running parallel to it. There is a N-S trending fault passing through the western margin of the Shillong Plateau. The continuation of this lineament is envisaged further north. The E-W trending Dauki fault separates the Bengal basin from the Shillong massif with a thin cover. The NW-SE trending Kopili fault passing in between Shillong and Mikir Massif can be traced from the Naga-Arakan-Yoma thrust belt to Tibet across Brahmaputra alluvium. The Naga-Arakan-Yoma arcuate fold belt is traversed by NW-SE and NE-SW faults and fractures. The eastern margin is affected by a series of thrusts and further east, lies at the Central Burma Tertiary Molasse basin. The Shan Boundary Fault runs along a N-S direction between the Central Burma Molasse basin and Shan plateau. The inner Myitkyina and Mandalay Ophiolite belt is truncated by Shan fault to the north. Mishmi Hills occupying the north eastern corner of the India has NW-SE trending high angle frontal thrusts *viz.*

the Mishmi thrust and Lohit thrust besides other lineaments having the same trend (Nandy, 1973; 1981).

ii. The Bouger gravity anomaly map prepared by Nandy (1986) for the region shows the following features :

a. The anomaly varies from +40 milligals in the southern margin of Shillong Plateau to -550 milligals in the Trans Himalayan region.

b. The contour in general, run E-W with a minor kink along the belt of schuppen and a major deflection along the Tsangpo suture. The gradient is flat to gentle in the Lesser Himalayasn zone north of MBT.

c. The steep gravity gradient across the southern margin of Shillong Plateau significantly marks the contact of thick sedimentary pile in northern Bengal Basin and Sylhet Trap along the Dauki fault.

d. The northeastern corner of the Bengal Basin is characterised by E-W elongate contour with a minima of -70 milligals at northeast of Dacca whereas in the main Bengal Basin, the contour trend NE-SW with values varying from -20 to 30 milligals.

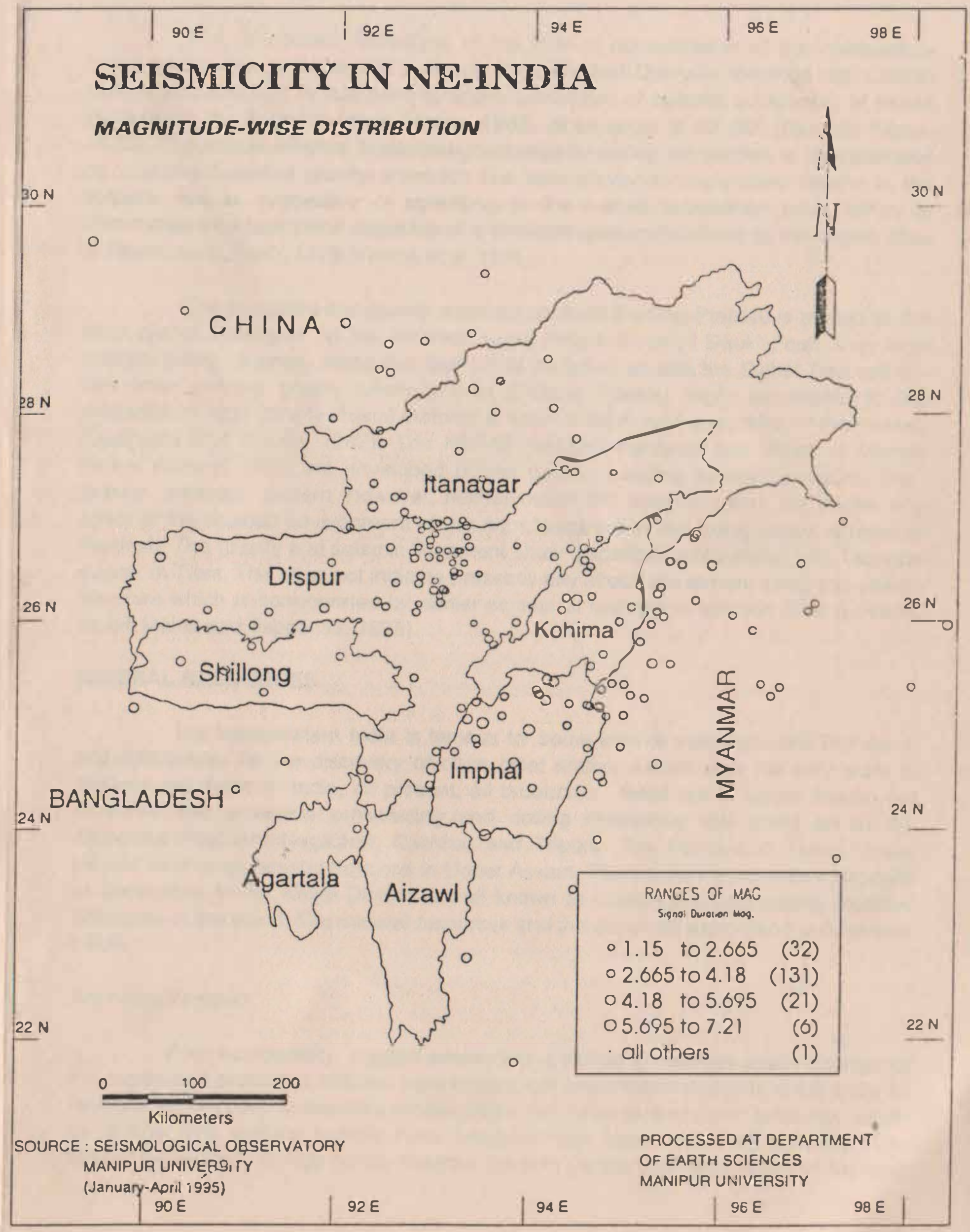
e. In south Burma Basin, Naga-Arakan belt and Central Burma Molasse Basin, the arcuate gravity contours parallel the tectonic trend.

f. The zone between the eastern margin of Indo-Myanmar Orogen and Central Volcanic line is characterised by a gravity minima with the lowest value of -175 milligals.

Seismicity

Northeast India is considered to be one of the six most potential sites of strong earthquakes in the world. Earthquakes in this belt are shallow to intermediate depth (upto 200 km.). The focal depths increase towards Myanmar where the continental land mass is subducting eastwards. Earthquakes of this region is mainly due to Main Boundary Thrust (MBT), Naga-Thrust, Haflong Thrust, Dauki Fault and other numerous lineaments. Focal mechanism of the earthquakes has shown thrust-faulting along the MBT, Naga-Thrust, Arakan-Yoma belt and Haflong Thrust. Strike-slip is also indicated for some earthquakes. Normal faulting is indicated in Arakan-Yoma belt for some earthquakes.

A prominent historical earthquakes of this region occurred in 1897 in Shillong Plateau with a magnitude of about 8.7 (Richter Scale). A recent prominent earthquake was in 1988 with a magnitude of 7.3, where its epicenter was along the Manipur-Myanmar border area. The latest large earthquake occurred in with Jan.1990, its epicenter located along the Manipur-Myanmar border. These indicate. the area to be seismically very active and the region needs attention for Geoscientists.


SEISMICITY IN NE-INDIA
MAGNITUDE-WISE DISTRIBUTION
90 E
92 E
94 E
96 E
98 E
30 N
28 N
26 N
24 N
22 N
N
CHINA
Itanagar
Dispur
Kohima
Shillong
Imphal
MYANMAR
BANGLADESH
Agartala
Aizawl
RANGES OF MAG
Signal Duration Mag.
1.15 to 2.665 (32)
2.665 to 4.18 (131)
4.18 to 5.695 (21)
5.695 to 7.21 (6)
all others (1)
0 100 200
Kilometers
SOURCE : SEISMOLOGICAL OBSERVATORY
MANIPUR UNIVERSITY
(January-April 1995)
PROCESSED AT DEPARTMENT
OF EARTH SCIENCES
MANIPUR UNIVERSITY

An array of 45 (forty five) analog accelerographs has been installed in parts of Assam and Meghalaya in 1985, covering a major portion of Northeast India. The network includes a grid pattern (10-40 km.) in which prominent/ active thrust are selected for installation of accelerographs.

The concordant disposition of the zone of concentration of the intermediate focus earthquake epicenters in between the outer belt Ophiolite melange and Central Burma Volcanic Line is indicative of active subduction of oceanic component of Indian plate below the Burmese block (Nandy, 1982), at an angle of 40°-60° (Das and Filson, 1975). The narrow arcuate flysch trough developed during subduction is characterised by a strong Negative gravity anomaly. The zero gravity anomaly zone parallel to the volcanic line is suggestive of upwelling of the melted subduction crust, which is corroborated by fault plane solutions of a few earthquakes incidence in this region (Das & Filson, op.lit; Fitch, 1979; Verma *et.al.* 1976).

The elongated low gravity anomaly south of Shillong Plateau is related to the thick pile of sediments on the southern down thrown block of Dauki Fault. Very high positive gravity anomaly along this fault could be linked up with the Sylhet Trap volcanism while positive gravity anomaly over Shillong Plateau might be related to the presence of high density crustal material at shallow depth and up arching of the plateau (Dasgupta and Nandy, 1982). The NW-SE trending fractures and thrust of Mishmi Nexus (Nandy, 1981) are enveloped by the parallel trending seismic contours. The gravity anomaly pattern, however, neither depict this tectonic trend, nor shows any effect of the copious development of the Abor Volcanics in the Siang valley, Arunachal Pradesh. The gravity and seismic lineament show discordant relationship with Tsangpo suture, in Tibet. This does not indicate presently any stress adjustment along this palaeo structure which is corroborated by earlier studies of fault plane solution (Das & Filson, *op.cit*. Molna and Tapponeir, 1975).

MINERAL RESOURCES

The Northeastern India is famous for some mineral resources like Petroleum and Sillimanite. Till the discovery of oil in other states, Assam was the only state to produce petroleum in India. At present, all production fields are in Upper Assam but intensive and extensive prospecting and drilling operations are going on in the Arunachal Pradesh, Nagaland, Cachhar and Tripura. The Barail and Tipam Group include several oil bearing horizons in Upper Assam. The sillimanite-corundum deposits of Sonapahar in the Khasi District is well known to contain the best quality massive sillimanite in the world. The mineral resources and the status on exploration is described below :

Arunchal Pradesh

Poor accessibility, rugged terrain and a limited knowledge about geology of the region had prohibited detailed investigations of any mineral deposits in the state till recently. An ore body of sulphide mineralisation has been probed down to 60 mts depth by drilling. The surface sample have indicated high cobalt value up to 2.2%. The significant deposits of high grade dolomite occur in Dedza and Rupa areas of Kameng

district. Graphite flabes occur in graphite schist and gneiss, with graphite content varying from 3-20% on visual estimation. The graphite occur within the sillimamite zone, near Laddak on Zero Daporio area of Subansiri district. These two lenses indicate a reserve of about 23.25% tonnes of graphite. The Tidding limestone in Lohit district is known to be suitable for manufacture of Portland cement.

Assam

Assam has a vast mineral resources in general and fuel in particular. There are various coal fields in Upper Assam where the thickness of coal seam varies from 2 mts to 12 mts. The important coal fields are Delhi-Jaipur, Makum coal field, Mikir and Cachhar hills etc. A thick deposit of limestone extends more or less, as a continuous belt, along the southern base of Meghalaya plateau. There are a few prominent oil fields located in Assam and producing a considerable amount of oil and gas. The Digboi oil field has a stratigraphic thickness of about 1,065 mts. It produces 9,000 tones oil approximately. The Nahorkatiya oil field is another major oil field. The Moram oil field is located near Nahorkatiya and is similar to it. Recent investigations at Rudrasagar and Teak of Sibsagar district indicated a promising reserve of oil in the area.
The total of important minerals in Assam are given below :

Petroleum	: 87.8 million tonnes
Natural gas	: 44.45 million cubic mts.
Coal	: 342.02 million tonnes
Limestone	: 1054 million tonnes

Manipur

No significant mineral resources have been reported so far due to lack of exploration. However, the chromite, limestone, copper, and nickel are reported but of little economic significance. A mini cement plant is recently setup at Hundung, Ukhrul district.

Meghalaya

The potentiality of initiation or expansion of mineral based industries in Meghalya mainly depends on four principal mineral deposits *viz.* limestone, coal, sillimanite,radioactive minerals and clay. The extensive belt (200 km long) of good quality limestone occurring along the southern border of the state, opens a new vista of exploitation of these deposits with the emergence of Bangladesh market. At present 74,000 tones of limestone is raised annually. The next important mineral is coal confined to the Tertiary of Garo and Khasi hills with an annual output of about 40,000 tonnes. The sillimanite is found as massive form scattered in 27 major or minor deposits in Nongstoin area and is famous for its properties as natural refractory. It occurs in association with corundum. The state is endowed with a number of deposits of fire clay and China clay which are likely to sustain the future refractory and pottery industries. Recently radioactive minerals are also reported from Bomisiat.

Mizoram

No major mineral deposits of economic importance have been reported so far in the state. The massive, hard, compact bluish-ash to grey coloured lower and upper Bhuban sandstone are being used as road metal in different parts of Mizoram. Indication of occurrence of oil, saline springs have been reported. It requires further exploration.

Nagaland

There are some mineral deposits of little economic value in Nagaland. They are asbestos, chromite, coal, limestone, magnetite, nickel, cobalt, chromium, pyrite, slate, phyllite and zinc. Recently ONGC has started the exploratory operations for oil & natural gas. Several oil seepages close to the thrust contact between Tipam and Barails have been found within the Barail sandstone all along the hill slopes.

Tripura

The most important mineral resources of the state are oil and natural gas, glass sand, pottery clay, building materials ect. Oil and natural gas in the state is mainly explored by ONGC.

REFERENCES

Acharyya, S.K., 1982. Structural framework and tectonic evolution of the Eastern Himalayas. Him. Geol.,10,412-439.

Allegre, C. J. *et. al.*, 1984. Structure and evolution of the Himalaya-Tibet orogenic belts. Nature, 307,17-22.

Anonymous, 1980. A scientific guide book to the South Kizang (Tibet). Symp. Qinghai Xizang (Tibet) Plateau, Acad. Sinica, Peking, 104.

Chattopadhyay, B. & Chakravarty, S. 1984. Northeast corner of Indian Plate - an appraisal. Rec. Geol. Surv. Ind., 113(4),62-66

Das, S. and Filson, J., 1975. On the tectonics of Asia. Earth Planent. Sci. Lett., 28,244-253.

Dasgupta, A. B., 1979. Petroleum occurrence in the terrain adjoining the north-eastern Himalaya, Geol. Surv. Ind. Misc. Pub.,41(5).

Dasgupta, S. & Nandi, D. R., 1982. Seismicity and tectonics of Meghalaya plateau, N.E. India, Proc. VII Symp Earthquake Engg. Univ. Roorkee, 1,19-24.

Fitch, T. J., 1979. Earhquake mechanisms in the Himalayan, Burmese and Andaman regions and continental tectonics in Central Asia, Geophy. Res. Jour., 75,2699-2709.

Mathur, L. P. & Evans, P., 1964. Oil in India. 22nd Int. Geol. Congr. New Delhi, 86p.

Mitchell, A. H. G., 1981. Phanerozoic plate boundaries in Mainland SE Asia, the Himalayas and Tibet. Jour. Geol., London, 138, 109-122.

Molnar, P. & Tapponier, P., 1975. Cenzoic tectonics of Asia : effects of continental collision, Science, 189,419-426.

Moore, G. F. *et. al.*.1980. Variations in geological structure along the Sunda fore arc. NE Indian ocan. In tectonic and geological evolution of SE Asia Seas and Islands, Geophys. Monograph., Mayes, D. K. (Ed.), 23, 145-160.

Nandy, D. R., 1973. Geological and structural lineaments of Lohit Himalayas (Arunachal Pradesh and adjoining areas-a tectonic interpretation) Proc. Sem. Geodynamics of the Himalayan Region. Hyerabad. IUGS. 167-172.

Nandy, D. R., 1981. Tectonic pattern of northeastern India and adjoing region. Ind. Jour. Earth Sci. 7(1), 103-107.

Nandy, D. R., 1982. Geological set-up of the eastern Himalaya and the Patkoi-Naga-Arakan Yoma (Indo-Burman) hill ranges in relation to the Indian Plate movement. Proc. Sem. Himalayan Geology, New Delhi. 1976, Misc. publ., 41(2A), 205-213.

Nandy, D. R., 1983. The eastern Himalayas and the Indo-Burman orogen in relatin to the Indian plate movement. Geol. Surv. Ind. Misc. Publ., 43, 153-159.

Nandy, D.R., 1986. Tectonics, seismicity and gravity of northeast India and adjoining region. Mem. Geol. Surv. India. 119, 13-17.

Rao, A., 1983. Geology and hudrocarbon potential of a part of Assam-Arakan basin and its adjacent region. In Petroliferous Basins of India. Petroleum Asia Jour., Dehra Dun, Bhandari, L. L., et al (Ed.). 127-157.

Shackleton, R. M., 1981. Structure cf southern Tibet : report on traverse from Lhasa to Kathmandu organised by Academia Sinica. Jour. Struc. Geol., 3(1), 97-105.

Tapponier, P. *et. al*.1981. Field evidences for active faulting in tibet. Nature, 294 (5840).

Verma, R. K. *et. al.* 1976a. Seismicity, gravity and tectonics of north east India and northern Burma. Bull. Sci. Soc. Amer., 66(5), 1683-1694.

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